BETTIS
Actuators & Controls
A Daniel Industries Company

Bettis Line Guard 2100

Introduction and Applications Overview Presentation

What is a Line Break Detector?

- Measures pipeline pressure
- Calculates average pressure and rate of pressure change
- Determines if abnormal line conditions exist
- Activates data storage function for detailed event evaluation
- Energizes solenoid to close valve

Development Background

- LineWatch 1400 / LineGuard 2000
- Merger with Daniel Industries
- Daniel Flow Computer platform
- Shafer/ Bettis/ Daniel development team
- Interviews with industry leaders

LineGuard 2100 Functionality

- Monitors line pressure every 5 seconds
- Monitors rate of Drop in pressure (ROD/Min)
- Configurable pressure average samples
- Detects Major and Minor events

LineGuard 2100 System Configuration

- Date & Time support (Local Time)
  - Read and set via Modbus
- Sanity values in database
- Y2K compliant
- Processor sleep mode
- Local display configurable in rotating or scrolling mode.

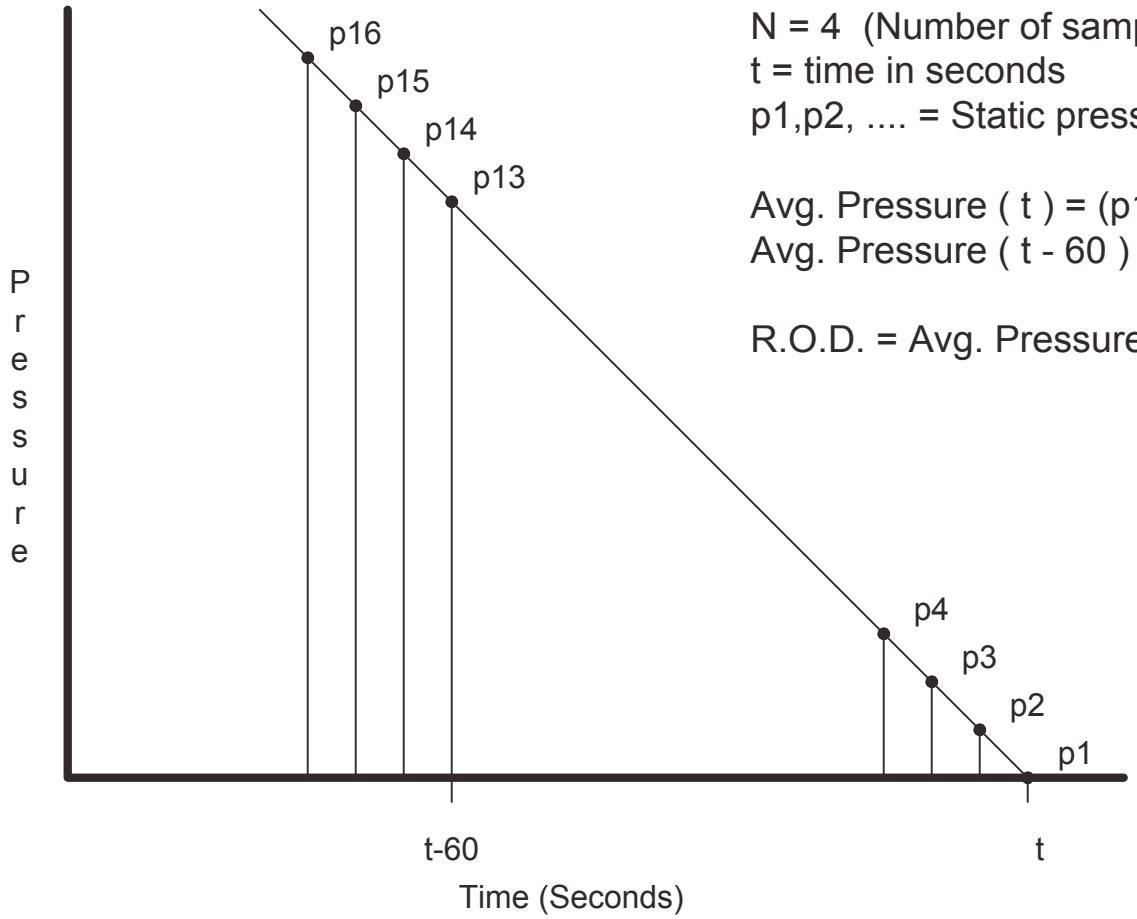
LineGuard 2100 Sensors

- Supports Druck or 1-5 Volt pressure sensors (Ver. 2)
- Support for Fixed/Live inputs
- Logs downloadable in ENRON format

Sensor Calibration

- On line sensor calibration will be added to the LineGuard in the near future
- Up to five calibration points per sensor

R.O.D. Calculation

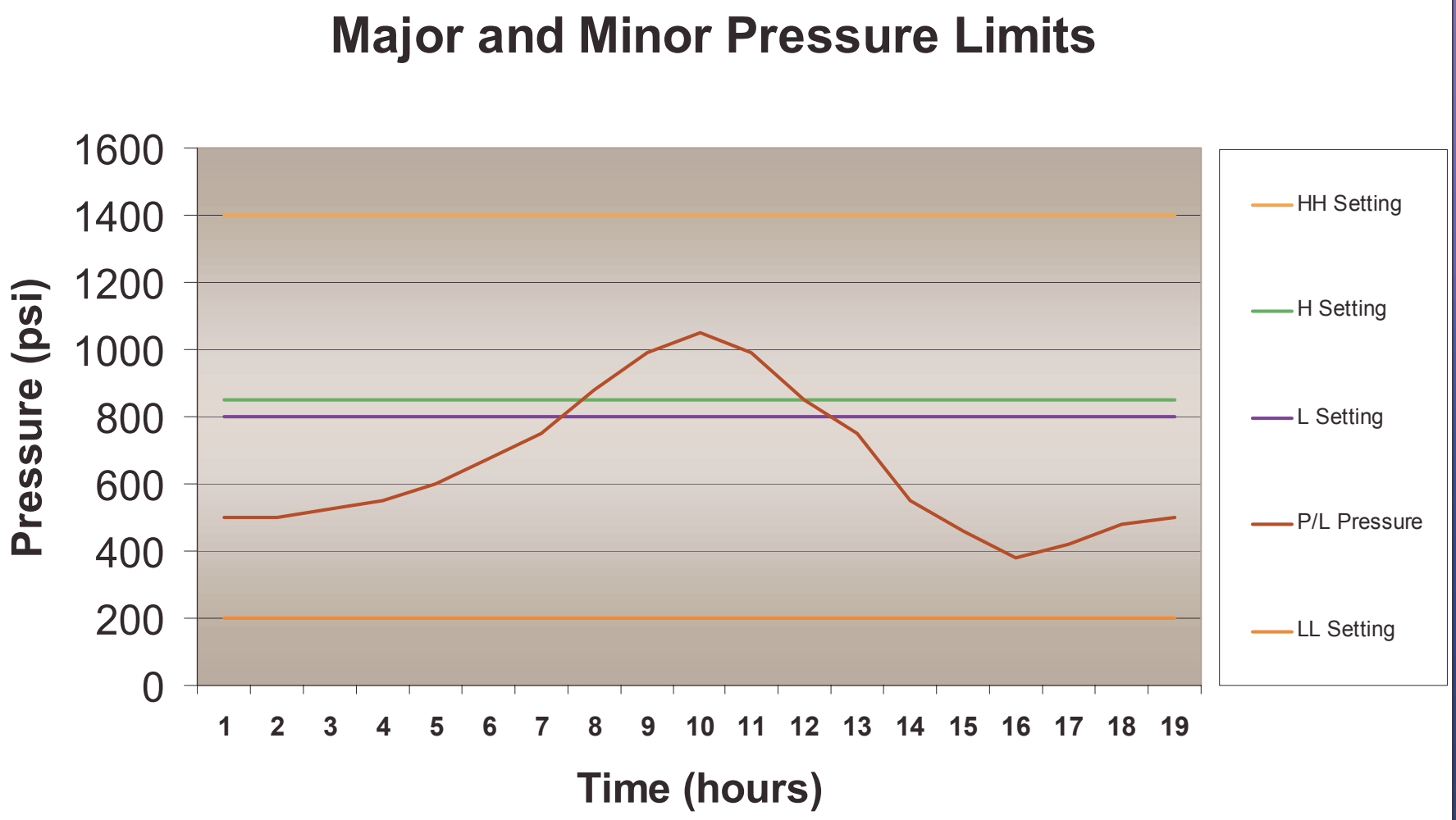


N = 4 (Number of samples)
t = time in seconds
p1,p2, ... = Static pressure samples at 5 second intervals.

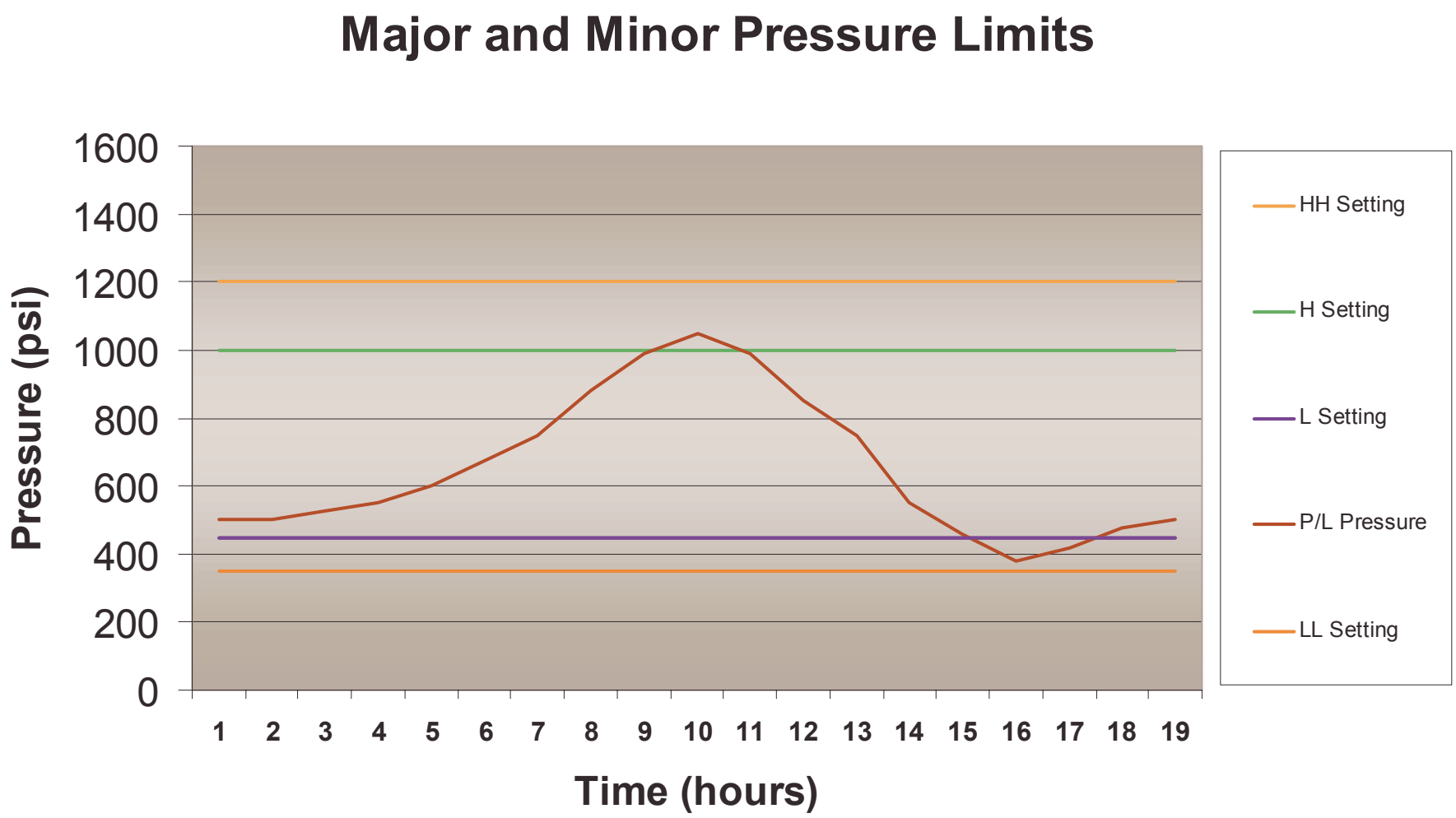
Avg. Pressure (t) = (p1+p2+p3+p4) / 4
Avg. Pressure (t - 60) = (p13+p14+p15+p16) / 4

R.O.D. = Avg. Pressure (t - 60) - Avg. Pressure(t)

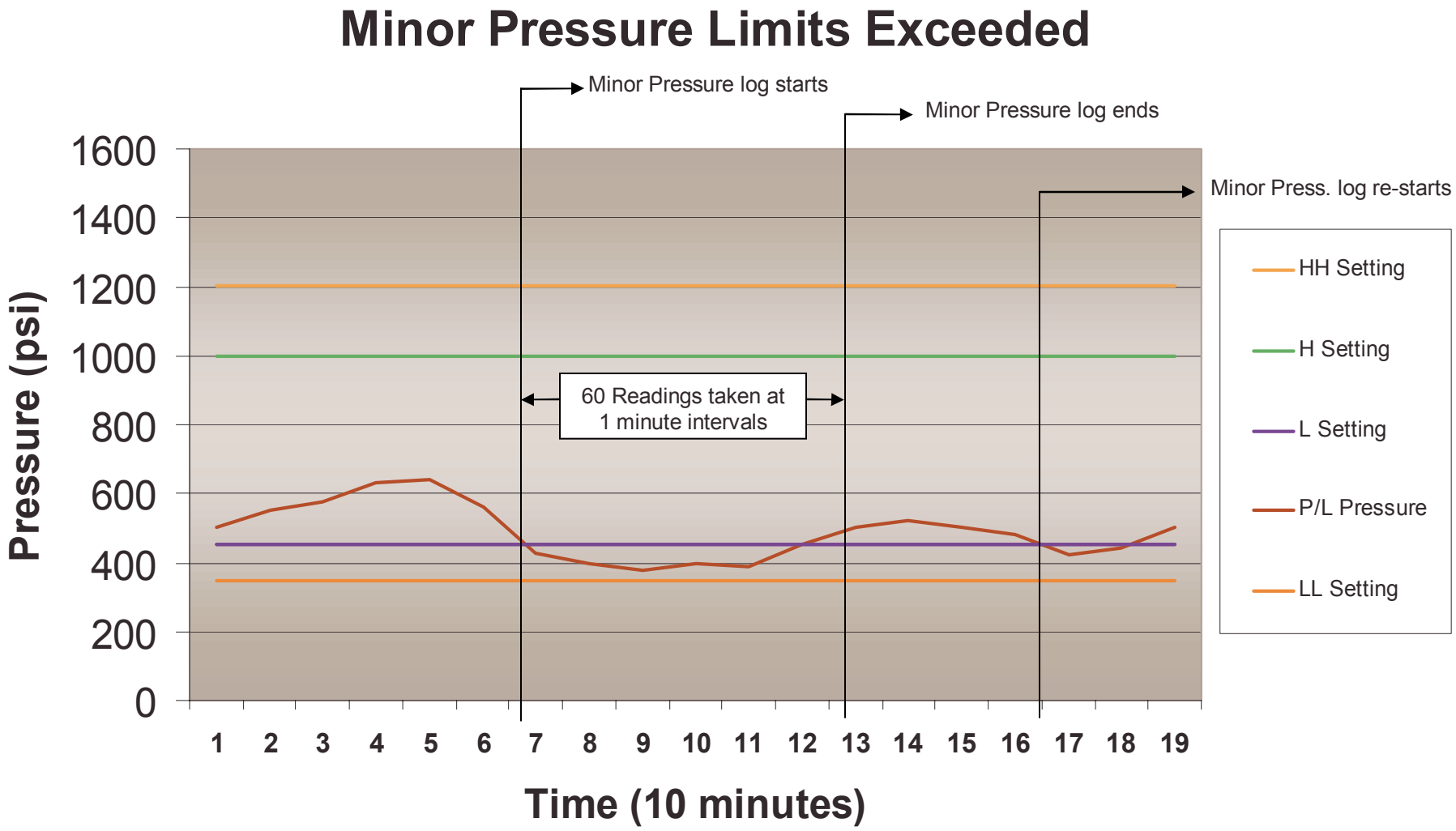
Setpoint Illustration - New Location



Setpoint Illustration - Defined Location



Setpoint Illustration - Minor Logging



LineGuard 2100 Minor Event

- Minor event triggered by
  - High Pressure Setpoint
  - Low Pressure Setpoint
  - High Rate of Pressure Drop (ROD)
- Triggers may be individually disabled
- Minor event triggers Minor Event logs for both pressure and ROD

LineGuard 2100 Major Event

- Major event triggered by
  - High-High Pressure Setpoint
  - Low-Low Pressure Setpoint
  - High-High Rate of Pressure Drop (ROD)
- Triggers may be individually disabled
- Major event triggers Major Event logs for both pressure and ROD

LineGuard 2100 Data Logs

- **Minor Pressure - Records pressures after minor event**
- **Minor ROD - Records ROD after minor event**
- **Major Pressure - Records pressures before and after major event**
- **Major ROD - Records ROD before and after event**

LineGuard 2100 Minor Event Log

- Readings are logged following the event
- Interval between readings is configurable, 30 sec to 5 minutes
- Average pressure and ROD is logged
- A total of 100 records
- 60 Pressure and ROD readings per record

LineGuard 2100 Minor Event Log

- 30 minutes to 5 hours of pipeline history per record
- 100 records before over-writing of oldest data
- 2 to 20 day duration of pipeline history retained

Minor Event Logs….

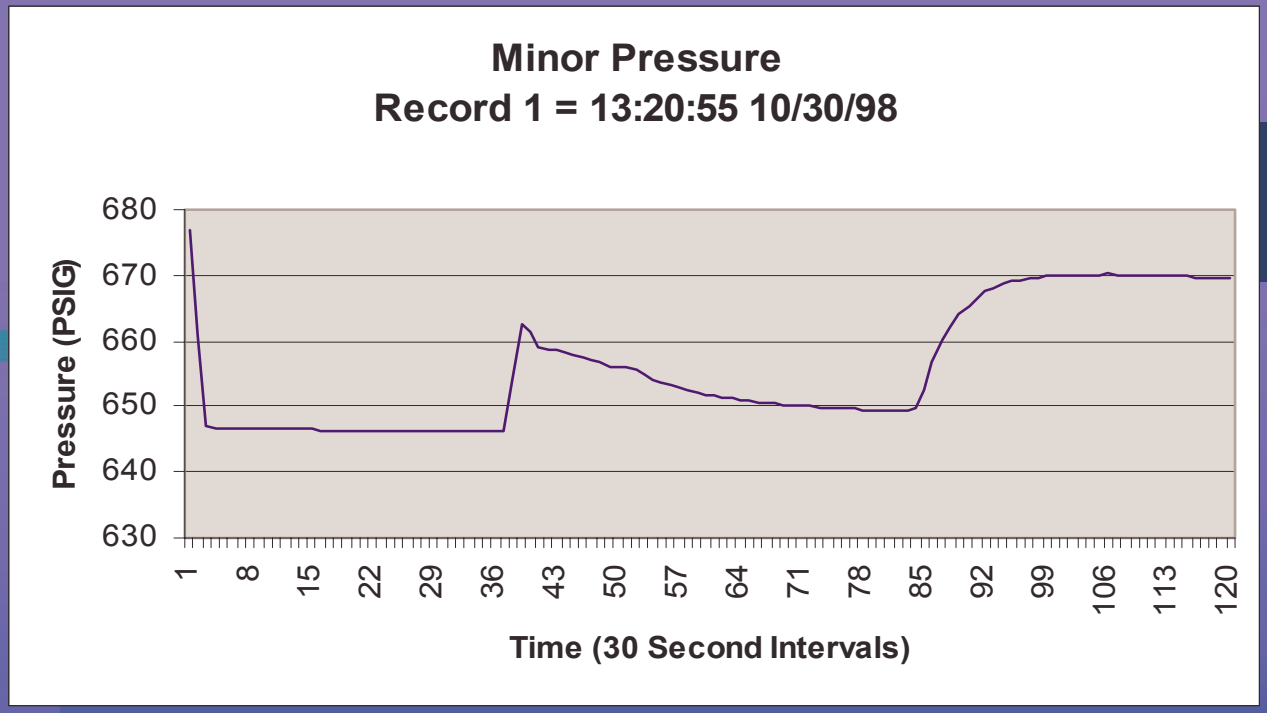
	Readings							
	1	2	3	4	5	6	thru	60
Records	61							
	121							
	181							
	241							
	301							
	361							
	421							
	481							
	541							
	601							
	.							
	.							
	.							
	5941							6000

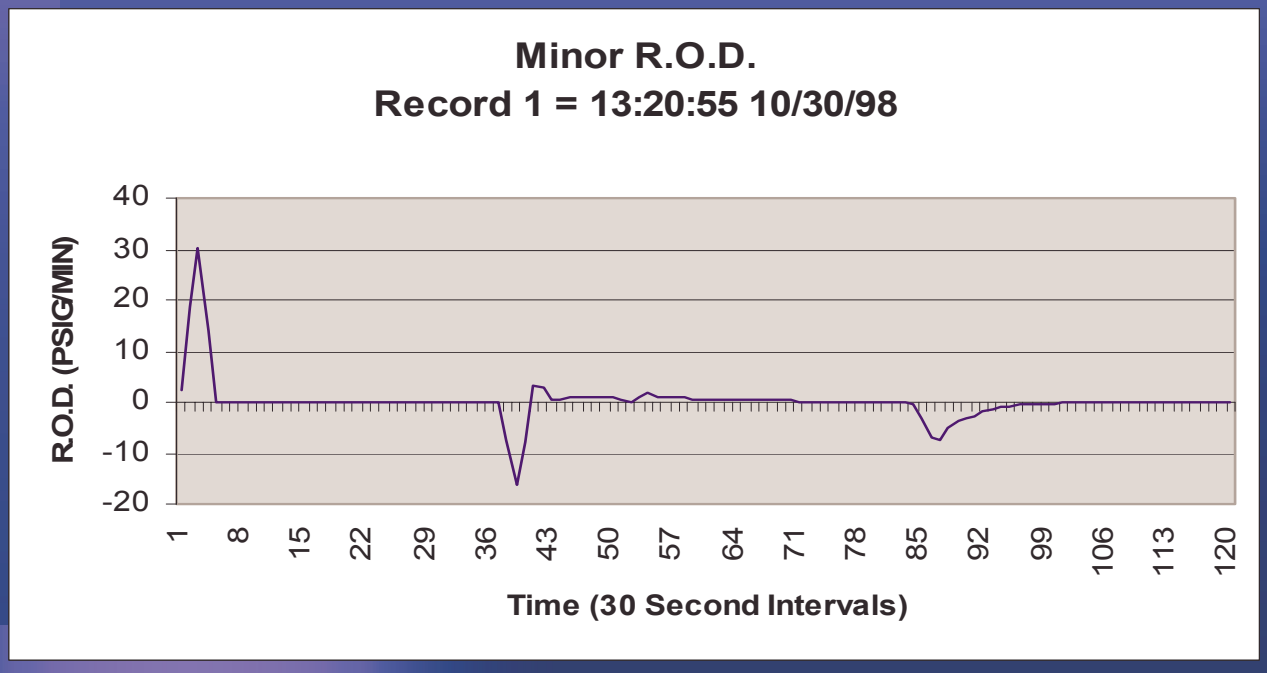
LineGuard 2100 Major Event Log

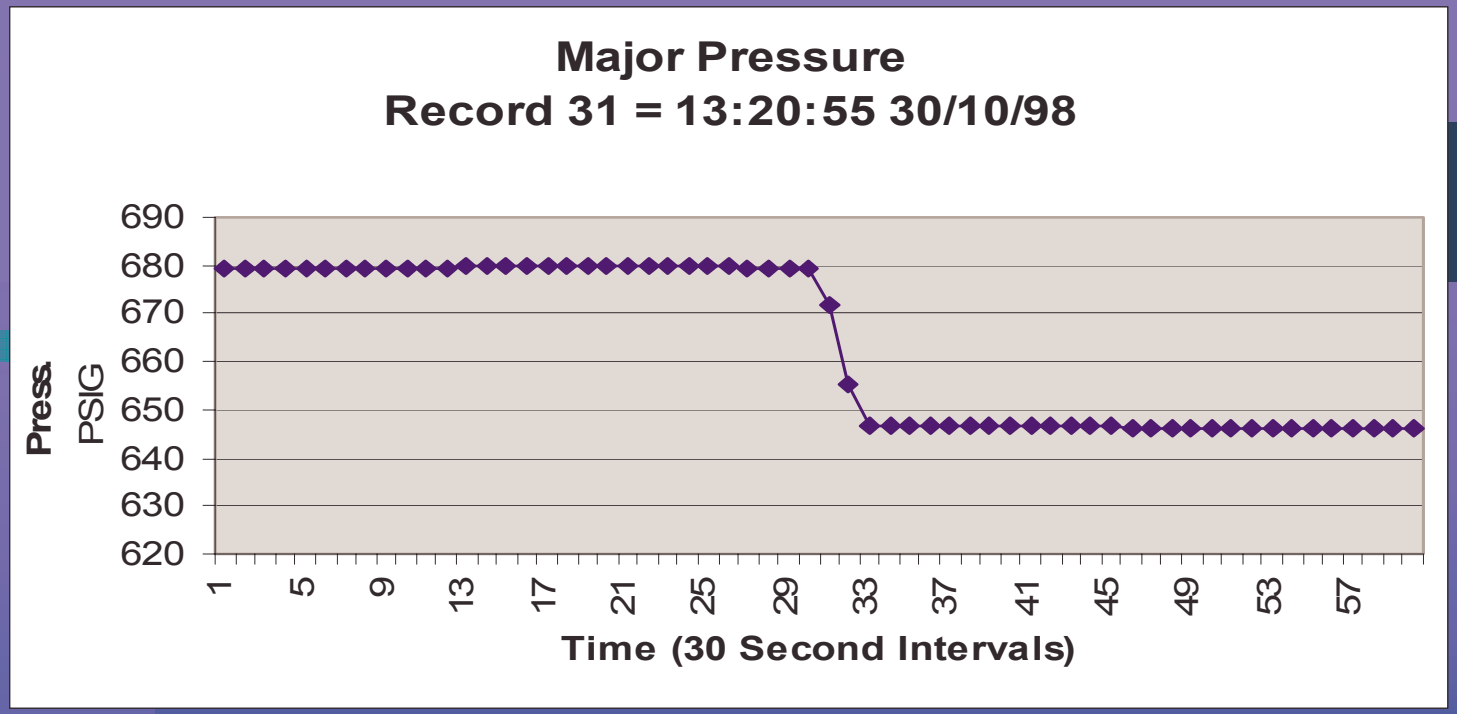
- Readings are logged before and after the event
- Interval between readings is configurable: 5, 10, 15, 30 seconds
- 1 Record of 60 readings
- 60 Pressure and ROD readings per record: up to 30 before and at least 30 after

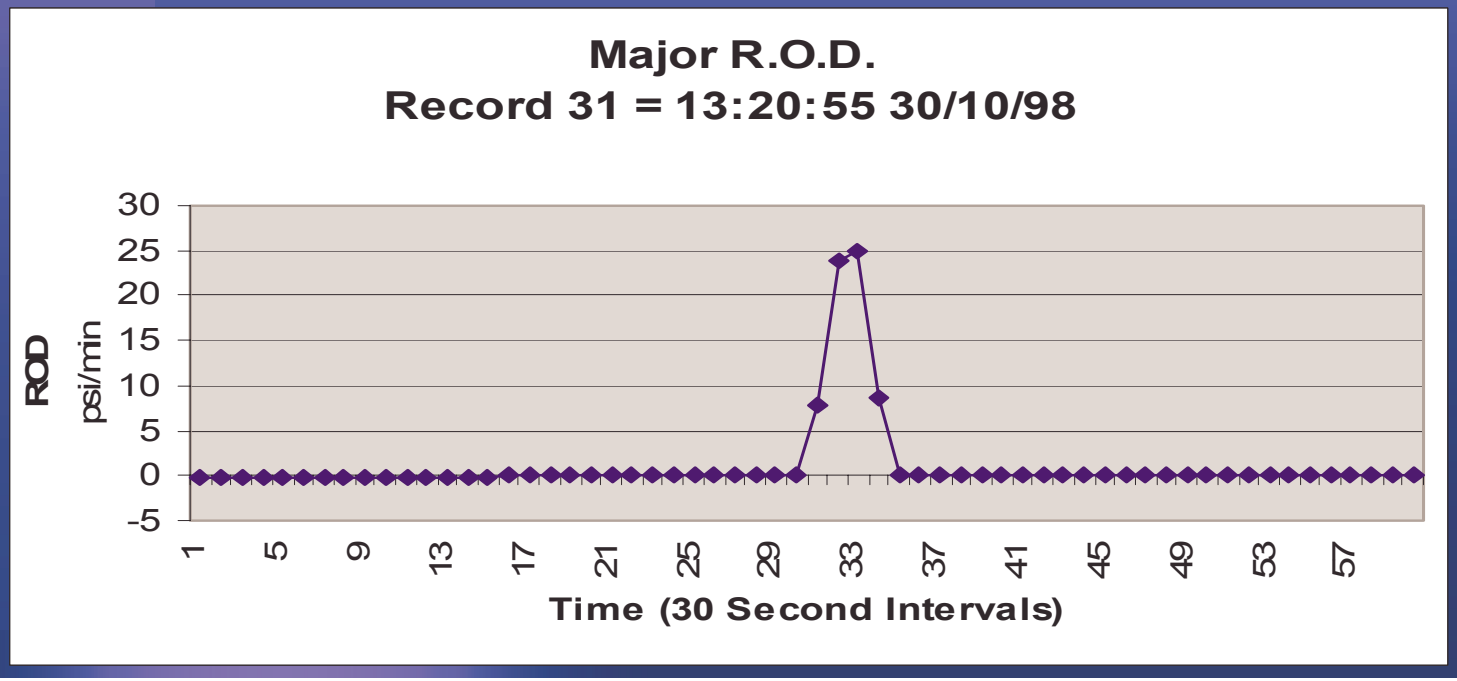
Typical Event Log in MS Excel Format

Date	Time	Event Type	Data Point	Old Value	New Value
03/02/99	16:46:44	Event	Guard State	MANUAL-O	MANUAL-C
03/02/99	16:46:45	Event	Valve State	OPEN	UNKNOWN
03/02/99	16:46:46	Event	Valve State	UNKNOWN	CLOSED
03/02/99	16:46:49	Event	Guard State	MANUAL-C	MANUAL-O
03/02/99	16:46:50	Event	Valve State	CLOSED	UNKNOWN
03/02/99	16:46:52	Event	Valve State	UNKNOWN	OPEN
03/06/99	8:59:51	Event	Major Log Intrvl	30	5
03/06/99	9:00:30	Event	Test/Live Mask	000000ff	000000fe
03/06/99	9:00:45	Event	Guard State	MANUAL-O	AUTOTIME
03/06/99	9:01:15	Event	Guard State	AUTOTIME	AUTO-C
03/06/99	9:01:23	Event	Valve State	OPEN	UNKNOWN
03/06/99	9:01:24	Event	Valve State	UNKNOWN	CLOSED
03/06/99	9:00:40	Alarm - Active	Hi RoD Setpoint	10.49	10
03/06/99	9:00:45	Alarm - Active	HH RoD Setpoint	15.74	15
03/06/99	9:01:35	Alarm - Cleared	Hi RoD Setpoint	7.26	10
03/06/99	9:01:35	Alarm - Cleared	HH RoD Setpoint	7.26	15
03/06/99	9:07:00	Alarm - Active	Hi Pres Setpoint	70.75	70
03/06/99	9:14:00	Alarm - Active	HH Pres Setpoint	80.1	80
03/06/99	9:16:40	Alarm - Cleared	HH Pres Setpoint	80	80
03/06/99	9:17:05	Alarm - Active	Hi RoD Setpoint	10.56	10
03/06/99	9:17:15	Alarm - Cleared	Hi Pres Setpoint	68.8	70
03/06/99	9:17:25	Alarm - Active	HH RoD Setpoint	15.76	15
03/06/99	9:17:45	Alarm - Cleared	HH RoD Setpoint	14.99	15
03/06/99	9:18:05	Alarm - Cleared	Hi RoD Setpoint	8.76	10
03/06/99	9:36:35	Alarm - Active	Hi RoD Setpoint	10.85	10
03/06/99	9:36:55	Alarm - Active	Lo Pres Setpoint	39.56	40
03/06/99	9:37:05	Alarm - Cleared	Hi RoD Setpoint	9.1	10
03/06/99	9:40:35	Alarm - Active	LL Pres Setpoint	29.11	30
03/06/99	9:40:45	Alarm - Active	Hi RoD Setpoint	10.17	10
03/06/99	9:41:35	Alarm - Cleared	Hi RoD Setpoint	9.74	10
03/06/99	9:42:00	Alarm - Cleared	LL Pres Setpoint	32.84	30
03/06/99	9:42:15	Alarm - Cleared	Lo Pres Setpoint	41.42	40


Minor Pressure
Record 1 = 13:20:55 10/30/98
Pressure (PSIG)
680
670
660
650
640
630
1
8
15
22
29
36
43
50
57
64
71
78
85
92
99
106
113
120
Time (30 Second Intervals)


Minor R.O.D.
Record 1 = 13:20:55 10/30/98
R.O.D. (PSIG/MIN)
40
30
20
10
0
-10
-20
1
8
15
22
29
36
43
50
57
64
71
78
85
92
99
106
113
120
Time (30 Second Intervals)


Major Pressure
Record 31 = 13:20:55 30/10/98
Press.
PSIG
690
680
670
660
650
640
630
620
1
5
9
13
17
21
25
29
33
37
41
45
49
53
57
Time (30 Second Intervals)


Major R.O.D.
Record 31 = 13:20:55 30/10/98
ROD
psi/min
30
25
20
15
10
5
0
-5
1
5
9
13
17
21
25
29
33
37
41
45
49
53
57
Time (30 Second Intervals)

LineGuard 2100 Alarm and Event Logs

- **Alarm Logs**
  - 20 different alarm types
  - Indicates “Active” and “Clear” status
  - 200 alarm records, overwriting oldest
- **Operator Event Logs**
  - Records change in configuration or program settings
  - “Old” and “New” values are recorded
  - 100 operator records, overwriting oldest

LineGuard 2100 Alarm and Event Logs

- Combination of Operator Event and Alarm logs downloaded as 1 file
- Logs downloadable in ENRON format register 32
- Read, Clear, Reset event log functionality per ENRON Modbus (referencing datapoint rather than Modbus register)

Solenoid Operation

- Automatic closure triggered by major event exceeding event duration
- Closure selectable based on Low or High Pressure or ROD
- The event duration can be set to 30 sec, 1, 2, 3, 4 or 5 minutes
- Solenoid de-energised by programmable timer or by limit switch at end of valve travel

Solenoid….

- Remote communications “manual” closure
  - Password required
- Optional second solenoid for remote “manual” open via SCADA
  - Password required
- LineGuard 2100 does not support capability to automatically reset and re-open the line valve

Valve Status

- Monitors valve actuator position status
  - Open, Closed or In transit
  - Alarm on valve actuator travel duration exceeding pre-set limit
  - Travel duration configurable from 30 seconds to 5 minutes

Cold/Warm Start Functionality

Ability to:

- **Restart the computer without affecting data or logs**
- **Restart the computer, re-initializing the data but not the logs**
- **Restart the computer initializing both the data and logs**
- **Or put the computer into a known initialized default condition.**
- **Accomplished by: combinations of a reset (from software or the reset button), the dipswitch coldstart switch and the dipswitch re-arm switch.**

Dip Switch Function

Switch #1: Off - Warm Start

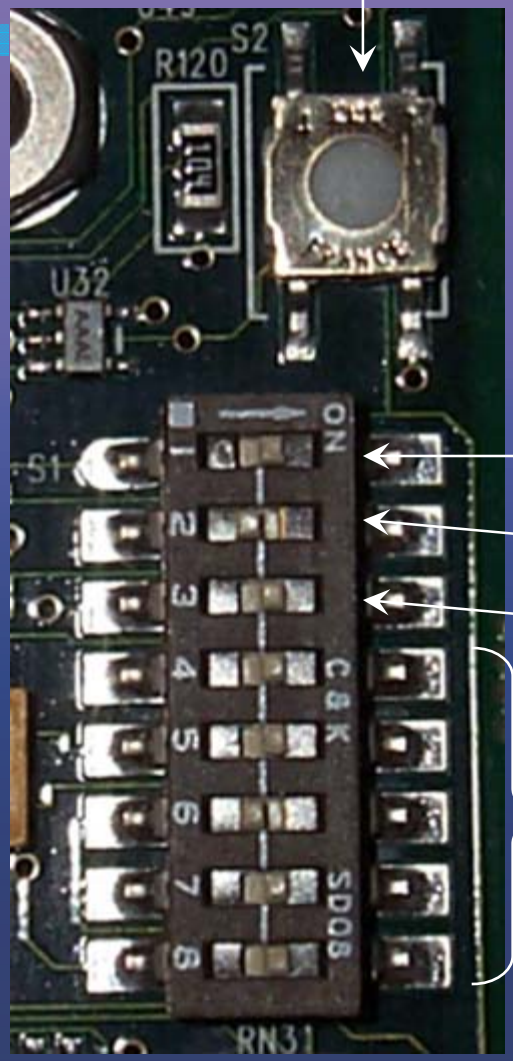
On - Cold Start

Switch #2: Off - Logs and Configuration retained

On - Logs cleared, Configuration retained

Switch # 3: Off - Adjust display contrast, start/stop auto scrolling

On - Use “+”, “-” keys scroll through all valid data points



Warm Start

- LineGuard 2100 data and code is maintained on a *Warm Start*, including online configuration changes
- Logging data retained or cleared as reset S1 #2 dipswitch is off or on during warm start
  - front panel confirmation required to clear logs (Ver. 2)
- Maintains the date and time when the unit was *Warm Started*.

Cold Start

- The code and configuration are recopied from Flash to RAM, overwriting any online changes
- If a configuration is present (config.dat) the factory default is overwritten by the configuration file.

Cold Start….

- **Logging data retained or cleared as reset S1 #2 dipswitch is off or on during cold start**
  - **front panel confirmation required to clear logs (Ver. 2)**
- **Maintains the date and time when the unit was *Cold Started*.**

LineGuard 2100 Communications

- Modbus ASCII support (Standard & Special)
- Configurable Modbus registers
- Field upgradable firmware
- Read/Write user level security
- Functional level security

User Logon Access Levels

sp65 Functions	Access Level		sp65 Functions	Access Level		sp65 Functions	Access Level		sp65 Functions	Access Level	
	Read	Write		Read	Write		Read	Write		Read	Write
Version Number	10	0	Valve State	10	0	A/D Type Input 7	10	10	RTS/CTS Channel 2	10	10
Major Sequence Numl	10	0	Enabled Alarms	10	0	A/D Type Input 8	10	10	Parity Channel 2	10	10
Minor Sequence Numl	10	0	Error CPU-PC	10	0	A/D Type Input 9	10	10	RTS Delay Port 2	10	10
Major Record Number	10	0	Error Number	10	0	Pressure Range	10	10	Modbus ID 2	10	10
Cold Date & Time	10	0	Error Status Register	10	0	Sensoe Serial Number	10	10	Protocol 2	10	10
Warm Date and Time	10	0	Date and Time	15	0	Static Pressure Type	10	10	Pressure K0	10	10
Main Battery Voltage	10	0	Minor Record Number	15	0	Average Samples	10	10	Pressure K1	10	10
Smart Pressure	10	0	Event Register	15	0	Event Duration	10	10	Pressure K2	10	10
Valve Open Output	10	0	Alarm Events	15	0	Autoclosure Mask	10	10	Pressure K3	10	10
Valve Open Output	10	0	Static Pressure in Use	15	0	Atmospheric Pressure	10	10	Pressure K4	10	10
Valve Open Input	10	0	Language	15	5	Test / Live Mask	10	10	Pressure K5	10	10
Valve Close Input	10	0	Application	15	8	Calibration Status	10	10	Temperature K0	10	10
Input 1 A/D Count	10	0	Date Format	10	10	Valve Close Time	10	10	Temperature K1	10	10
Input 2 A/D Count	10	0	Display Scroll	10	10	Valve Open Time	10	10	Temperature K2	10	10
Input 3 A/D Count	10	0	Diplay Timeout	10	10	LL Pressure Alarm	10	10	Temperature K3	10	10
Input 4 A/D Count	10	0	Location ID	10	10	L Pressure Alarm	10	10	Temperature K4	10	10
Input 5 A/D Count	10	0	LineGuard Awake	10	10	H Pressure Alarm	10	10	Temperature K5	10	10
Input 6 A/D Count	10	0	Test Pressure	10	10	HH Pressure Alarm	10	10	Ain1 K0	10	10
Input 7 A/D Count	10	0	Test Temperature	10	10	HH ROD	10	10	Ain1 K1	10	10
Input 8 A/D Count	10	0	Smart-P (Calibrated)	10	10	H ROD	10	10	Ain1 K2	10	10
Input 9 A/D Count	10	0	Analog Input 1	10	10	Battery Low Alarm	10	10	Ain1 K3	10	10
Digital Input 1	10	0	Analog Input 2	10	10	Comunications Channel	10	10	Ain1 K4	10	10
Digital Input 2	10	0	RTD Input	10	10	Baud Rate 1	10	10	Ain1 K5	10	10
Digital Input 3	10	0	Live Pressure Source	10	10	Word Size 1	10	10	Ain2 K0	10	10
Digital Input 4	10	0	EU Static Pressure	10	10	RTS/CTS Channel 1	10	10	Ain2 K1	10	10
Dip Switch	10	0	BU Battery Voltage	10	10	Parity Channel 1	10	10	Ain2 K2	10	10
Average Pressure	10	0	A/D Type Input 1	10	10	RTS Delay Port 1	10	10	Ain2 K3	10	10
ROD per Minute	10	0	A/D Type Input 2	10	10	Modbus ID 1	10	10	Ain2 K4	10	10
Guard State	10	0	A/D Type Input 3	10	10	Protocol 1	10	10	Ain2 K5	10	10
Active Alarms	10	0	A/D Type Input 4	10	10	Comunications Channel	10	10	Minor Log Interval	10	10
Major Event Status	10	0	A/D Type Input 5	10	10	Baud Rate 2	10	10	Major Log Interval	10	10
Minor Event Status	10	0	A/D Type Input 6	10	10	Word Size 2	10	10			

Modbus Register List

- **Associates the various database points with a Modbus register number for access by remote host systems.**

Types of Datapoints

- **Values**
  - **Floating: e.g. Pressures, Alarm limits**
  - **Integers: e.g. display timeout**
- **Selection Types**
  - **Baud rate, type of sensor**
- **Bitmaps**
  - **Alarms enabled, fixed/live mask, dip switch setting**

Modbus Data Types

- **Basic type:**
- 1 byte boolean
- 2 byte signed integer
- 4 byte signed integer
- 4 byte IEEE floating point
- 20 byte string
- **Special type:**
- clock register
- data log register
- event log register
- data log configuration register

Documents

- LineGuard Brochure No. 44.00
- Service Manual No. RD-00170
- Programmers Manual No. RD-00171

Environmental Testing

Transducer specs verified

Complete unit temperature cycle tested

Manufacturing Plant

LineGuard Assembly Area

Plant Instruction and Demonstration

Training and Site Testing

Site configuration and testing